Many out of one: Multicoupler basics

By Harold Kinley

What do you do when your "boxes" outnumber your available "sticks"? In this business, it is often necessary to feed more than one receiver from a single antenna connection. This is generally referred to as *multicoupling*. Techniques to accomplish this vary widely, depending on the available signal level and other factors such as required isolation and good engineering practice. Methods of multicoupling range from the simple to the complex, so let's start with the simplest arrangement.

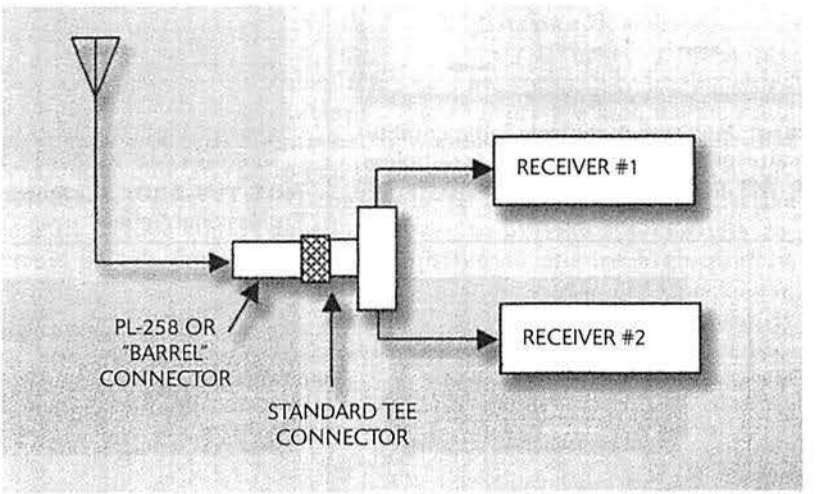

Figure 1. The simplest way to feed two receivers from a single antenna is to use the 'tee' connector arrangement shown here. It should only be used when isolation between receivers is not necessary and the signal level is adequate for division between the receivers.

'Tee' connector method

In the basic setup shown in Figure 1 above, we need to feed the inputs of two receivers from a single antenna. A simple "tee" connector is used to split the antenna line for each receiver input. This type of direct connection does not maintain the 50Ω system impedance and does not provide any isolation between the receiver ports (tee connector). This arrangement is only used when lack of isolation is not a problem and the signal level is fairly high (not near the receiver threshold sensitivity).

More than two receivers can be combined by using more tee connectors. For example, two tee connectors can be used to feed a single antenna to three receivers as shown in Figure 2 on page 32. The number of tee connectors required to provide N outputs is equal to $N - 1$.

Resistive network method

Another simple method used to provide multiple outputs from a single source is the *resistive method*. The size of the resistors, such as in Figure 3 on page 32, is calculated as:

$$R = Zo(N-1)$$

where

Z_o = system impedance (50Ω)

N = the number of outputs

The loss between the input port and either output port will be 6dB for the divider with two output ports. The loss will be greater for dividers with more output ports. The loss between the input and any output port can be calculated as

$$L = 20\log\left[\frac{1}{N}\right]$$

where

L = loss in decibels

N = number of output ports

The system impedance will be maintained, and some small amount of isolation will be between receivers. However, the resistive-divider network is inefficient and usually an undesirable way to provide multicoupling.

Transmission-line transformer

To maintain a constant 50Ω system impedance, a quarterwavelength transmission line of the proper characteristic impedance can be used as an *impedance transformer*. For example, to feed the input of two receivers from a single antenna, using a simple tee connector as a splitter will reduce the impedance at the splitter input to about 25Ω. This is because the two 50Ω receiver inputs are connected in parallel and thus produce a 25Ω impedance.

If the 50Ω impedances of the receiver inputs were to be transformed to 100Ω and then combined at the tee connector, the resultant impedance would be 50Ω. This would maintain the integrity of the 50Ω system impedance. You can closely approximate this by using a quarterwavelength of 75Ω transmission line. To transform the 50Ω receiver-input impedance to 100Ω would require a quarterwavelength of transmission line with a characteristic impedance of 70.7Ω. This is calculated as:

$$Z_O = \sqrt{50Z}$$

where

Z_o = the characteristic impedance of the transmission line

Z = the impedance to be transformed. This formula also can be rearranged as:

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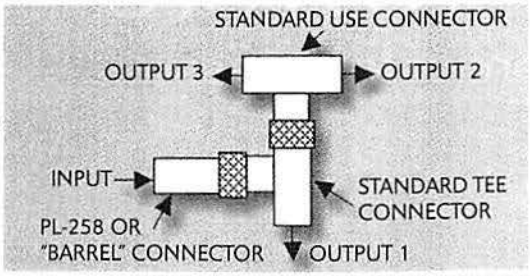

Figure 2. An input signal split three ways with two tee connectors. The number of tee connectors required is $N-1$, where N is the number of desired outputs.

$$Z = \frac{Zo^2}{50}$$

This will provide the resultant impedance when using a quarter-wavelength section of transmission line of characteristic impedance, Z_O, on a device with a 50Ω impedance. Transmission lines with a characteristic impedance of 70.7Ω are not readily available, but 75Ω transmission lines *are* readily available. So, substituting 75 into the formula we have:

$$Z = \frac{75^2}{50} = 112.5\Omega$$

This means that connecting a quarterwavelength section of 75Ω transmission line to an impedance of 50Ω will yield an impedance of 112.5Ω at the input, as shown in Figure 4 on page 34. This impedance of 112.5Ω is purely resistive, and it is properly written as $112.5 \pm j0\Omega$.

Now, to combine two 50Ω receiver inputs, we could use two quarter-wavelength lines, as shown in Figure 5 on page 34, to produce an impedance of 56.25Ω at the input to the tee connector. This would produce a VSWR of 1.125:1—a good impedance match.

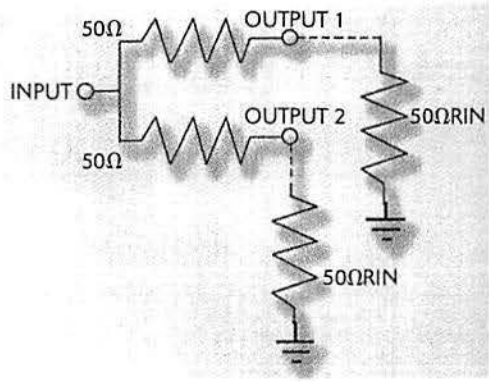

Figure 3. Two 50Ω resistors form a splitter network to feed two receiver inputs. The number of resistors needed to make such a resistive splitter equals the number of outputs needed. The value of the resistor is $Z_O(N-1)$, where Z_O is the system impedance (50Ω for our purposes) and N is the number of outputs needed. For two outputs, we need 50Ω resistors in the divider network. The two 50Ω resistors shown connected to the outputs of the divider network represent the input impedance of the receivers.

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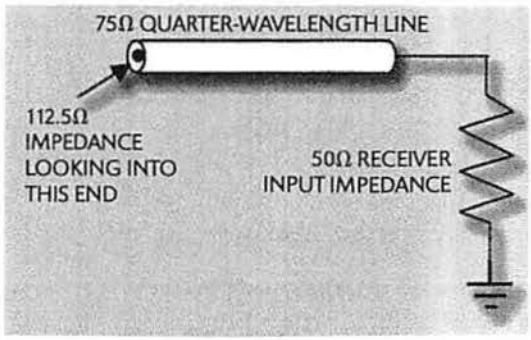

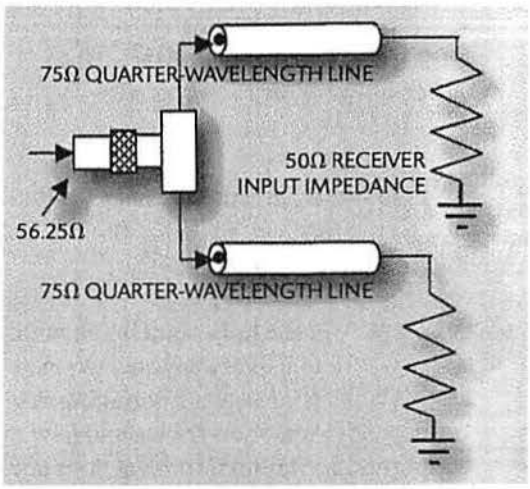

Figure 4 (top). A quarterwavelength of 75Ω transmission line transforms a 50Ω impedance into an impedance of 112.5 ± j0Ω at the other end of the transmission line. Figure 5 (bottom). Two quarterwavelength 75Ω transmission lines provide an impedance match to a 50Ω system while splitting the input to two 50Ω receivers. The impedance 'looking into' the input side is 56.25Ω It provides a close match to the 50Ω system impedance.

When cutting the transmission line to the proper quarterwavelength, it is necessary to account for the velocity factor of the transmission line. Remember, too, that *odd multiples* of quarterwavelength may be used, for practical purposes.

To divide the input into three outputs, quarterwavelength sections of RG-62 coax could be used. The characteristic impedance of RG-62 is 93Ω. Terminating it with the 50Ω receiver input will transform the impedance to 173Ω at the other end. Three of these connected in parallel would produce an impedance of 173 ÷ 3 = 57.6Ω for a VSWR of 56.6 ÷ 50 = 1.132:1 at the input to the divider. This is close enough for practical purposes. Similarly, a 1:4 divider could be fashioned using four quarterwavelengths of RG-62. Because 173 ÷ 4 = 43.25Ω, this will produce a VSWR of 50 ÷ 43.25 = 1.156:1 at the input to the divider.

A commercially produced receiver multicoupler is the recommended way to go. Such multicouplers are usually designed as rack-mount units with a built-in preamplifier and hybrid power splitter, along with the necessary power supply. Dividing the input signal among several receivers will necessarily reduce the amount of signal level available at each output port.

For example, the *theoretical* insertion loss of a two-port divider is 3.0dB, for a three-port divider, 4.8dB, and for a four-port divider,

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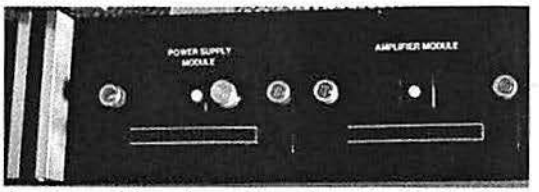
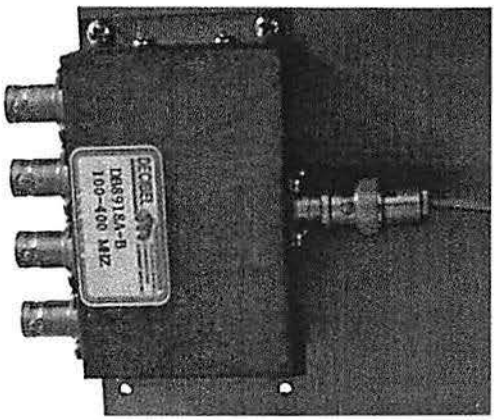


A commercial-grade multicoupler unit.



A commercial multicoupler's signal divider is usually mounted on the back of the chassis.

6dB. In practice, the insertion loss will be greater than that, but it can never be *less* than that. Therefore, if you see an ad specifying insertion loss *less than the theoretical minimum,* you can usually take that to mean that the insertion loss is that amount *plus* the theoretical minimum.

In commercial multicouplers, a low-noise preamplifier usually precedes the power divider, as shown in Figure 6 at the right. This will provide the best noise figure for the system. A high degree of isolation is also provided between the output ports for receiver-receiver isolation. When purchasing a commercial multicoupler, look closely at specifications such as: frequency range and bandwidth, receiver-receiver isolation, third-order intercept point, VSWR, system gain, noise figure, power requirements and preselector.

A commercial multicoupler unit includes a power supply and preamplifier, which are modular and can be easily removed for servicing. A signal divider is usually located on the rear of the chassis. A low-noise, high-gain preamplifier is used to overcome the losses of the

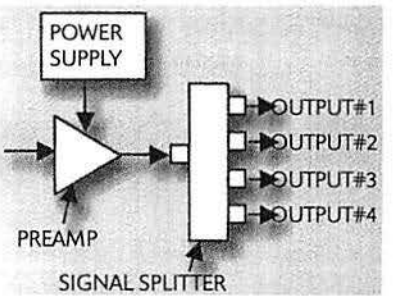


Figure 6. A typical receiver multicoupler provides a low-noise preamplifier preceding the signal divider. The amplifier should also have a high third-order intercept point for good IM rejection. The divider should provide a high degree of isolation between output ports. Any unused output port should be terminated in a 50Ω impedance.

divider while maintaining a low noise figure.

Homemade signal dividers might be useful in a given situation, such as an emergency. However, to maintain a system with optimum performance, use a commercial-grade multicoupler unit.

Until next time—*stay tuned!* ■

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